## Space Weather Technical Forecast

Issued on Monday 13 January 2025 at 01:08 Local

**This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

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**Space Weather Forecast Headline: Chance of isolated M-class flares. Slight chance of G1-G2/Minor-Moderate Geomagnetic Storms early Day 1 (13 Jan).**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity has been Low during the last 24 hours with only occasional C-class flares.

There are nine sunspot regions on the visible disc. AR3947 remains the largest and most magnetically complex group, but with further slight decay evident among the intermediate spots. AR3956 is located in the northeast, but nearing centre disc, and remains a simple, mature region. Most of the other regions remain small and simple with limited overall change. However, a single large spot is now rotating into view around the northeast limb, with a tentative initial classification of Hhx/Alpha.

No Earth-bound CME's were observed during this period.

**Solar Wind / Geomagnetic Activity:** Solar winds observed at L1 by ACE/DSCOVR have slowly declined through the period from 440km/s to 390km/s. The density of the solar wind was mainly below average. The Interplanetary Magnetic Field, Bt, was predominantly weak, with the north-south component, Bz, also weak, varying between -7nT and +7nT. The Phi angle was mainly positive (away from the Sun). Geomagnetic activity was mainly Quiet (Kp 1-2), with an isolated Unsettled (Kp 3) interval 11/1500-1800UTC.

**Energetic Particles / Solar Radiation:** High energy proton flux (greater than 10MeV) at GOES-18 was at background levels. High energy electron flux (greater than 2MeV) at GOES16 was at background to moderate levels. The associated 24 hour fluence remained below the Active threshold on a slight declining trend, reading 1.06e7 integrated pfu at 13/0000UTC.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Generally Low, with a chance of isolated M-class flares and a very slight chance of isolated X-class flares, mainly due to AR3947 in the northwest disc or any spots that rotate over the eastern limb later in the period.

**Solar Wind / Geomagnetic Activity:** Solar winds are now at background levels were they are likely to remain during Day 1 (13 Jan). There is a slight chance of a CME arrival early on Day 1, but

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this is highly uncertain due to coronagraph imagery gaps at the time. Fast winds from CH08/- are anticipated to bring some minor enhancement from early Day 2 (14 Jan).

Geomagnetic activity is expected to be mainly Quiet to Unsettled (Kp1-3) on Day 1 (13 Jan), but with a slight chance of G1 to G2 Minor/Moderate Storms should any CME influence be forthcoming (very low confidence). On Day 2 (14 Jan) activity is expected to increase to Unsettled to Active (Kp3-4) levels, following the onset of the HSS from CH08/-, with a slight chance of peak G1/Minor Storm conditions. Activity is then expected to return to Quiet to Unsettled levels from Day 3 (15 Jan).

**Energetic Particles / Solar Radiation:** GOES18 high energy proton flux is expected to remain at background levels, with only a slight chance of rising in response to any notable flares. GOES-16 high-energy electron flux is anticipated to rise to moderate to high levels during Day 1 (13 Jan), before decreasing to background levels on Day 2 (14 Jan) due to the influence of the HSS from CH08/-. Flux levels may then increase again to moderate to high levels towards the end of the period. Electron fluence is expected to remain below the active threshold throughout.

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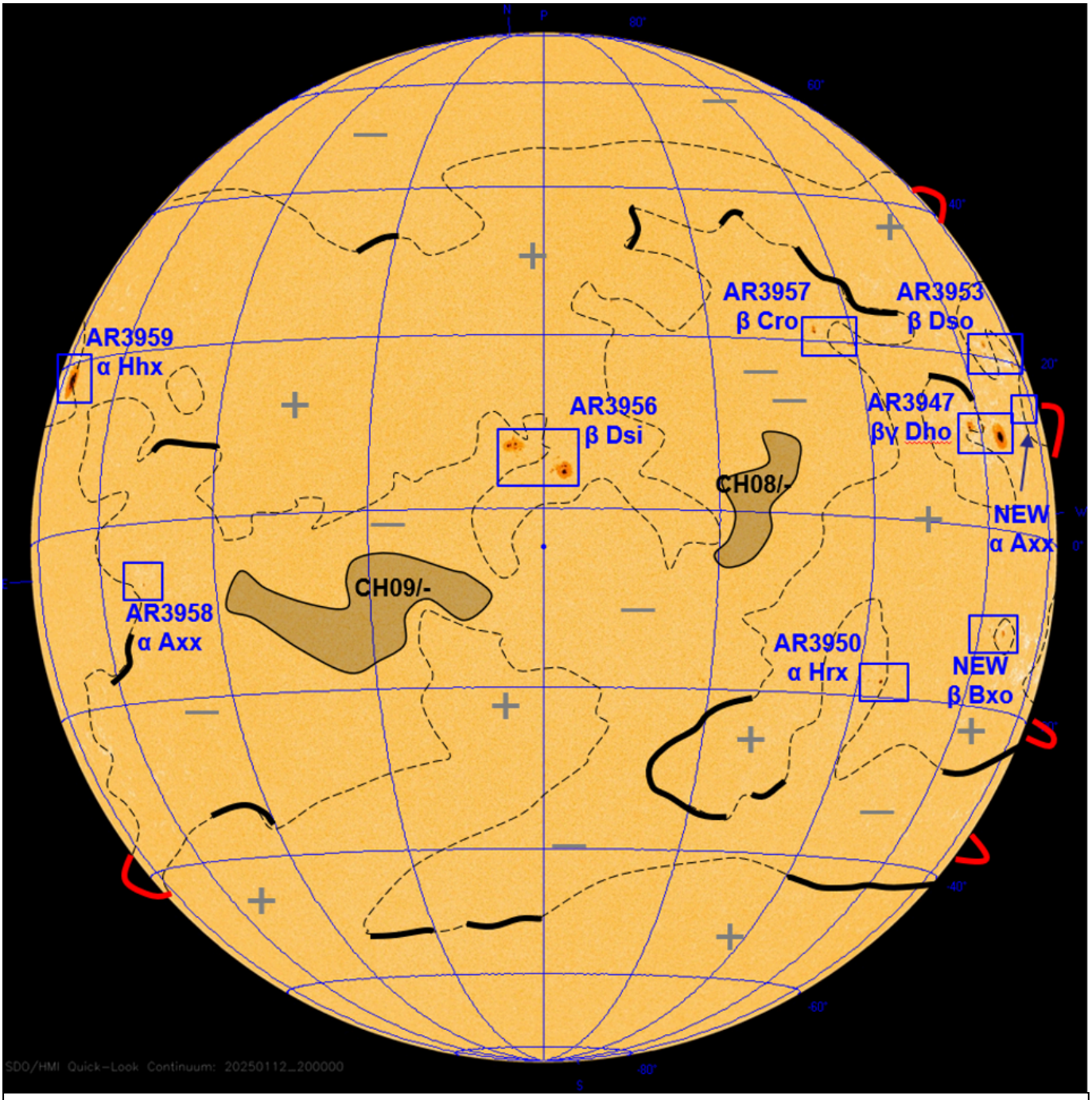
**Figure 1: MOSWOC Solar Synoptic Map valid 12/2000 UTC**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms

Solar winds have slowly declined towards background levels due to the waning connection to CH07/+, with observed speeds now around 390km/s. The next HSS enhancement is expected to be CH08/-, currently west of centre disc. Given its current location it is forecast to become geoeffective early on Day 2 (14 Jan) with speeds most likely increasing to slightly elevated to elevated levels. This timing is notably later than indicated by MOSWOC's Enlil model, which appears to overestimate both the size of CH08/- and the associated HSS speed. Speeds are then expected to gradually decrease back to background from Day 3 (15 Jan).

A filament eruption to the northeast of AR3947 appears on SDO/AIA 304 imagery and GONG H-alpha around 09/1030 UTC with an associated long duration C-class flare. Given the lack of SOHO and STEREO coronagraph imagery at the time, it is difficult to ascertain if any material was directed towards Earth as a result of this event. Given its location near centre disc, it was possible that we could have seen an Earth-directed component, however any CME would have likely reached earth by now. There remains a slight chance of an impact early on Day 1 (13 Jan), assuming a CME speed of approximately 1000 km/s, though this is highly uncertain. Due to this uncertainty, the potential CME has not been included in the "Earthbound Coronal Mass Ejections" table.

Geomagnetic activity is expected to be mainly Quiet to Unsettled (Kp1-3) on Day 1 (13 Jan), but with a slight chance of G1 to G2 Minor/Moderate Storms should any CME influence be forthcoming (very low confidence). On Day 2 (14 Jan) activity is expected to increase to Unsettled to Active (Kp3-4) levels, following the onset of the HSS from CH08/-, with a slight chance of peak G1/Minor Storm conditions. Activity is then expected to return to Quiet to Unsettled levels from Day 3 (15 Jan).

| Geomagnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 20 | 20 | 15 | 5 |
| Strong | G3 | No | 5 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

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## Radio Blackouts - X-Ray Flares

Solar activity has been Low during the last 24 hours with only occasional C-class flares.

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Evidence of magnetic looping in SDO 171 imagery near the eastern limb suggests the potential for new regions to rotate onto the facing-disc in the coming days. Helio-seismic data is supportive of this and corresponds to expected locations for Ex-AR3927, Ex-AR3929 and Ex-AR3933. The latter two regions were responsible for M-class flares when last on the disc in late December. AR3947, which currently dominates flare probability contributions, will rotate over the western limb on Day 2 (14 Jan).

Overall, there is a chance of M-class flares, with a very slight chance of isolated X-class flares, mainly due to AR3947 or any spots that rotate over the eastern limb later in the period.

| X-Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 (M Class) | No | 30 | 40 | 40 | 40 |
| Very Active | R3-R5 (X Class) | No | 5 | 5 | 5 | 5 |

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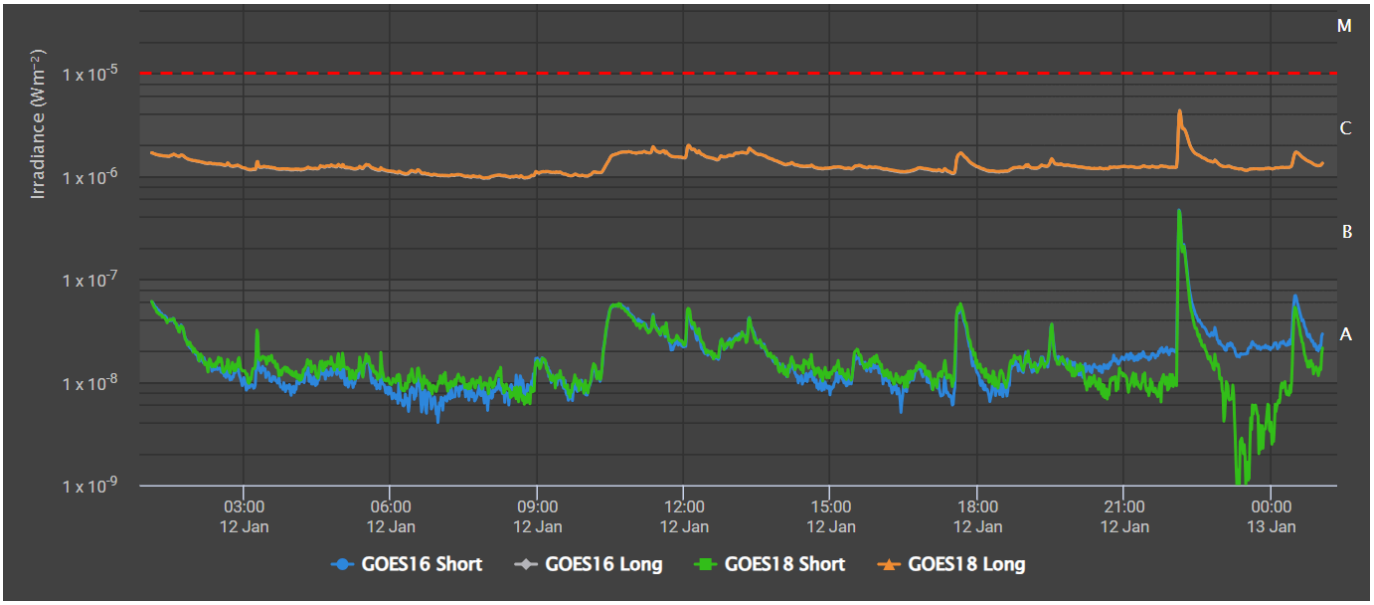
**Figure 2: GOES 16/18 X-ray Flux**



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## Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux has remained at background over the last 24 hours. There is a slight chance of an enhancement as AR3947, the most complex spot, continues to transit the western hemisphere during the forecast period, rotating off of the visible disc on Day 2 (14 Jan). This region was previously the source of many M-class flares and isolated X-class flares, but with a reduction in significant flares recently. Furthermore, there are a number of filaments currently on the disc, and it is not impossible that a large eruption from any of these could result in Earth-directed high energy protons.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}sr^{-1}s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 10 | 10 | 10 | 10 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

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## High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 has been at normal to moderate levels during the past 24 hours. As the connection to CH07/+ has continued to wane, we would expect the Van Allen belt to expand back to incorporate GEO and given the two recent fast wind events from an earlier connection to CH05/+ and now CH07/+ the electron belts are likely to have been charged up. As a result we may see electron flux rise on Day 1 (13 Jan), increasing to moderate, perhaps diurnally high levels. Complicating matters, however, is the possibility of a CME from the 09 Jan filament eruption possibly arriving early on Day 1 (13 Jan), which could see the electron belts becoming suppressed again. The anticipated arrival of the HSS from CH08/- on Day 2 (14 January) is also expected to suppress the electron belts away from GEO, with flux levels potentially returning to moderate to high levels towards the end of the period.

Electron fluence is expected to remain below the active threshold, with REFM currently serving as a reasonable guide. There is a slight chance of a slight rise later in the period, although this is fairly low confidence.

| GEO Electron Environment | Level ($cm^{-2}sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability (Exceedance) | | | (%) | (%) | (%) | (%) |
| Active | ≥ 2 MeV ≥ $1\times10^{8}$ | No | 1 | 1 | 10 | 10 |
| Very Active | ≥ 2 MeV ≥ $1\times10^{9}$ | No | 1 | 1 | 1 | 1 |

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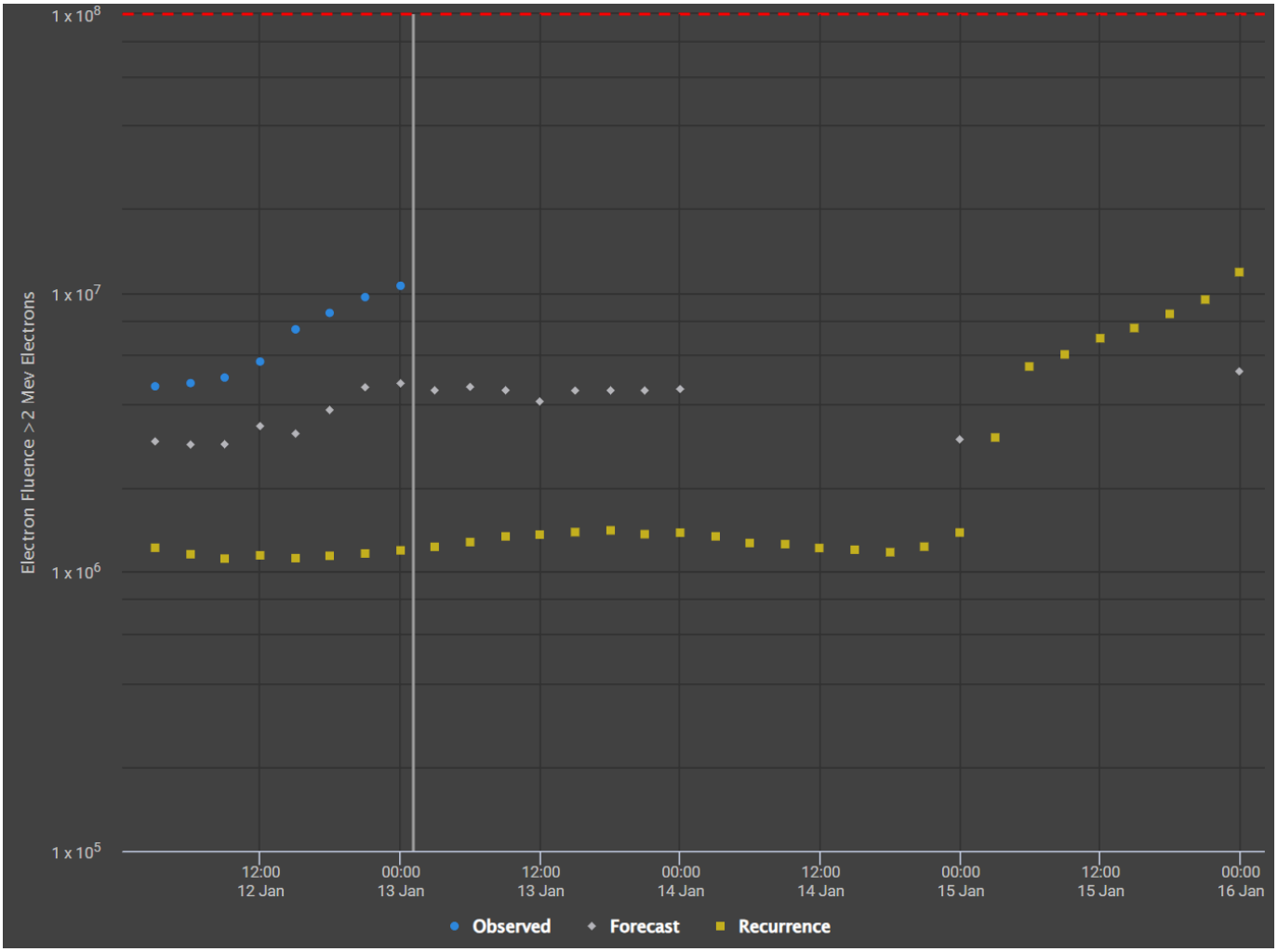
**Figure 3: MOSWOC REFM forecast and Recurrence**



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